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The self perceived effect of self-monitoring blood glucose (SMBG) on clinical and behavioral outcome among diabetic patients in Saudi Arabia

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ABSTRACT

Background: Self-monitoring of blood glucose (SMBG) is essential for optimal self-management of glycemic control. Objective: To assess diabetic patients and caregivers of diabetic patients' practices and satisfaction with SMBG usage in Saudi Arabia. *Methods:* Data was anonymously collected from participants across Saudi Arabia using a pretested questionnaire. Practices, experiences and satisfactions related to SMBG usage among diabetic patients and caregivers of diabetic patients were recorded. A modified version of the CGM Satisfaction Scale (CGM-SAT), which had 18 items, was used to record satisfaction regarding SMBG usage. All the data obtained data were tabulated and subjected to appropriate statistical analysis. *Results:* The majority of the diabetic patients demonstrated good satisfaction and the mean satisfaction score was found to be 74.0 ± 8.5 (maximum=90). No statistically significant differences were seen in satisfaction scores between the two genders and nationalities ($p>0.05$). However, satisfaction was significantly higher among those who used SMBG more than once a day ($p=0.029$), those who were on anti-diabetic medication ($p=0.004$) and those who were on insulin injection ($p=0.041$). *Conclusion:* Better self-glucose monitoring experiences are necessary for good treatment of patients with any type of diabetes and patient satisfaction is becoming increasingly important and widely recognized as a vital indicator of the quality of the healthcare system.

Keywords: Hyperglycemia, hypoglycemia, self-care, glucose monitoring.

1. INTRODUCTION

Diabetic patients regularly check their blood glucose levels to detect hypoglycemia and alter insulin doses as necessary. Self-monitoring of blood glucose (SMBG) can be a helpful technique in the management of diabetes (Kirk and Stegner, 2010). People who aren't diabetic also utilize SMBG to track their blood glucose levels and how they respond to dietary and pharmaceutical interventions (Karter, 2006). Asymptomatic hypoglycemia at sleep, glycemic excursions and postprandial hyperglycemia spikes, a known cardiovascular risk factor after meals, can all be detected by SMBG (Ceriello, 2005). The practice of SMBG enables patients to better understand their regular diurnal cycles ("glucose profile") and glycemic dynamics as a result of changes in diet, exercise, the introduction of new antihyperglycemic drugs and unusual clinical situations. SMBG could be an additional precautionary factor for individuals in high-risk occupations or activities that could result in severe outcomes if a metabolic event occurs. Making behavioral and therapeutic modifications while using SMBG might provide patients a sense of control over their own disease process, which can be empowering for patients. Studies show that SMBG practice may improve medication adherence, which in turn improves glucose control (Gilden et al., 1990; Soumerai et al., 2004). Patients treated with oral medications may also benefit from physician modifications in the kind and dosage of medication based on their home glucose readings, which may result in better outcomes.

SMBG management is contingent on the patient's knowledge of diabetes education and/or individual's ability to know the necessary fundamental steps for SMBG. Self-management success with diabetes necessitates the use of SMBG data. SMBG findings can benefit from goal planning from a health care and patient team perspective. If, for example, the findings of SMBG reveal a pattern of consistently high fasting glucose levels, drugs that target hepatic glucose production may be beneficial. Postprandial glucose levels reveal how food intake affects blood sugar levels. Changing one's diet or taking medication can both be effective treatments (Klonoff et al., 2008). Having the patients keep track of their SMBG numbers in a log book is a good idea. Interpreting the SMBG data requires knowledge of the subject's diet, medications and physical activity. In addition to helping the patient recognize their SMBG and consider possible alterations in exercise and nutrition, asking the patient to keep a log book will motivate the patient to track their SMBG. It is critical for the health care team to have the right information to make adjustments to the patient's medication and to prescribe lifestyle changes (such as increasing physical activity or stress coping methods) (American Diabetes Association, 2010).

In order to determine the best course of action for self-management, we must consider the importance of physical activity and diet. Self-care behavior objectives should be outlined as part of the treatment plan. SMBG treatment plans are patient specific. As a supplement to hemoglobin A1c, this can help differentiate pre-prandial hyperglycemia from postprandial hyperglycemia (Hershon et al., 2019). As a substitute, patients may choose to monitor their blood sugar levels at different times of the day and on different days of the week. The results of an SMBG taken before and two hours after a meal can provide the patient with rapid feedback on how their diet is working. Even when glycemic control appears to be acceptable, postprandial increases may be a separate risk factor for diabetes complications (Erbach et al., 2016). Patient comprehension and retention of SMBG's process, which can be complicated at times, need careful consideration. To have an effective SMBG, it is essential to focus on developing students' literacy and numeracy abilities. It is essential for the patient to demonstrate their SMBG to the diabetes educator or the health care practitioner.

A study conducted in the Makkah region reported a prevalence of 70.8% among Type 2 Diabetes Mellitus (T2DM) (Mansouri et al., 2015), where 28.2% of them practiced it once daily and 10.6% practiced it more than once daily. One-third (35.3%) of them logged their blood glucose levels. A Randomized control trial done in Nigeria with the aim of studying the effect of SMBG on glycaemic outcomes among T2DM patients reported significant improvement in HbA1c after SMBG (Sia et al., 2021). A Study done by Khamseh et al., (2011) reported that HbA1c improved significantly during a three-month period in all the T2DM patients and also diabetic patients with poor metabolic control. Scientific literature reporting the effect of SMBG among diabetic patients is often sparse in Saudi Arabia. Thus, this study aimed to assess the self-perceived effect of SMBG on glycaemic outcomes among diabetic patients in Saudi Arabia. The objectives of this researchwere: To assess the practices related to SMBG among adult diabetic patients and caregivers of pediatric diabetic patients. To assess the self-perceived effect of SMBG among adult diabetic patients and caregivers of the pediatric diabetic patients on glycemic outcomes.

2. MATERIALS AND METHOD

A cross-sectional study was done that covered participants from different provinces in the Kingdom of Saudi Arabia, during the period from 1st January to 31st July, 2022. A pretested self-reported questionnaire was used to collect data from adult diabetic patients and caregivers of pediatric diabetic patients. The participants' inclusion criteria will be:

- Diabetic patients aged >16 years above those who have the ability to self-report the questionnaire OR Caregivers of diabetic children OR Caregivers of geriatric diabetic patients (geriatric) who cannot self-report the questionnaire.
- Participants who give consent to participate and agree to complete the questionnaire.
- Saudi Arabian citizens or residents.

A mixture of convenience and snowball sampling was used to collect based on the above eligibility criteria. An online pretested self-reported anonymous questionnaire was used randomly send using social media platforms to get the responses. The first part of the questionnaire included items to identify the participants' eligibility, which includes whether they are diabetic and/or have children with diabetics and the sociodemographic. The second part had items that assessed the practices related to SMBG. The third part recorded the self-perceived effect of SMBG on clinical and behavioral outcomes on a 5-point Likert scale (5-strongly agree to 1-strongly disagree), which was a shortened version of the CGM Satisfaction Scale (CGM-SAT) (Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study Group, 2010). The original CGM Satisfaction Scale version is a 44-item scale, but our scale included 18 items.

Ethical consideration

Permission for conducting the study was taken from the Research and Ethics Committee of Taif University, with letter number (44-046).

Statistical Analysis and Data Management

All the collected information were tabulated on a Microsoft Excel sheet and then transferred to IBM Statistical Package for Social Sciences, Version 23 (SPSS Inc., Chicago, IL, USA) for data analysis. Descriptive statistics in the form of frequencies and percentages using suitable tables and figures were used to represent categorical data. Continuous variables were presented using mean and standard deviation. Comparison of continuous variables between categorical variables were evaluated using the students' t' test and/or Analysis of variance. A p value <0.05 will be considered statistically significant.

3. RESULTS

Our survey received 673 responses and the sociodemographic analysis showed that 506 (75.2%) were females, 634 (94.2%) were Saudi citizens, 228 (33.9%) were from the Western region of Saudi Arabia and 384 (57.1%) had bachelor's level of education. It was reported that 383 (56.9%) participants that they were diabetic and about 199 (62.2%) reported that they had Type 1 diabetes. About 166 (24.7%) participants have a child who suffers from diabetes and Type 1 diabetes (80.1%) was the most commonly reported diabetes among the children. The analysis also showed that there were 63 (9.4%) participants who were diabetic and also had a child who is diabetic, whereas 103 (15.3%) participants reported that only their child was diabetic, but they weren't (Table 1).

Table 1 Baseline characteristics of the participants

		N	%
Gender	Female	506	75.2
	Male	167	24.8
Nationality	Saudi	634	94.2
	Non-Saudi	39	5.8
Province	Central Region	108	16.0
	Eastern Province	115	17.1
	Northern Region	169	25.1
	Southern Region	53	7.9
	Western Region	228	33.9
Educational level	General education	229	34.0
	Bachelors/diploma	384	57.1
	Postgraduate	35	5.2

	Uneducated	25	3.7
Have diabetes	No	290	43.1
	Yes	383	56.9
Type of type of diabetes (n=320)	Type 1	199	62.2
	Type 2	92	28.7
	Don't know	29	9.1
Have child with diabetes	No	507	75.3
	Yes	166	24.7
Type of Diabetes child suffer (n=166)	Type 1	133	80.1
	Type 2	23	13.9
	Don't know	10	6.0
Gender of child	Female	90	54.2
	Male	76	45.8
Child is diabetic but parent is not diabetic	No	570	84.7
	Yes	103	15.3
Both parent and child are diabetic	No	610	90.6
	Yes	63	9.4

About 159 (95.8%) participants reported that their children were on anti-diabetic medication. Among those who used medication, about 133 (83.6%) used insulin injection and about 68 (42.8%) used it for more than three years. It is clear from the table and (Figure 1) that it was reported by 340(88.8%) of the participants that they use Self-monitoring of blood glucose (SMBG). Among those who used SMBG, about 195 (57.4%) participants used it more than once a day, 49 (14.4%) once a day, 22 (6.5%) more than once a week, 40 (11.8%) used it once a week, 19 (5.6%) more than once a month and 15 (4.4%) once a month. 263 participants reported that they received information on SMBG from the physicians. The majority of the participants (63.1%) who received information reported that they received information about the significance of SMBG, its use, method of operation and ways to cope with hyperglycemia and hypoglycemia. It was reported by 203 (59.7%) that they noticed a difference in blood sugar levels using SMBG from different sites. When we asked participants about the time of usage of SMBG, a majority reported that they used it before the meal (72.4%), whereas 12.1% used it after the meal, 39.4% after exercise, 35% before exercise, 48.5% for coping with hyperglycemia and 48.8% for coping with hypoglycemia (As shown in Figure 1). The most commonly used way to confirm SMBG device accuracy was manufacturer instruction. About 52.6% of participants reported that they sometimes noticed a discrepancy between estimated and actual SMBG, whereas 39 (11.5%) often noticed such a discrepancy. About 108 (31.8%) participants mentioned that they experienced problems with SMBG devices (Table 2).

Table 2 Practices and experiences related to Diabetes among participants and their children

		N	%
Children on anti-diabetic medication (n=166)	No	7	4.2
	Yes	159	95.8
Type of medication used (n=451)	Insulin injection	133	83.6
	Oral hypoglycemic medication	20	12.6
	Other	6	3.8
Duration of medications	<1 year	42	26.4
	1-2 years	49	30.8
	>=3 years	68	42.8
Use SMBG among those who are diabetic (N=383)	No	43	11.2
	Yes	340	88.8
Frequency of usage (N=340)	More than once a day	195	57.4
	Once a day	49	14.4
	More than once a week	22	6.5
	Once a week	40	11.8

	More than once a month	19	5.6
	Once a month	15	4.4
Received information (N=340)	No	77	22.6
	Yes	263	77.4
Contents of information received (n=263)	Significance of SMBG	74	28.1
	Use of SMBG	72	27.4
	How to operate	86	32.7
	Coping with hyperglycemia and hypoglycemia	62	23.6
	All of the above	166	63.1
	Other	4	1.5
Notices any level difference in blood sugar levels using SMBG from different sites	No	137	40.3
	Yes	203	59.7
Time of SMBG use (N=340)	Before meal	246	72.4
	After meal	41	12.1
	After exercise	134	39.4
	Before exercise	119	35.0
	For coping with hypoglycemia	165	48.5
	For coping with hyperglycemia	166	48.8
	Other	40	11.8
Ways of confirming SMBG device accuracy (N=340)	As specified by device manufacturer	172	50.6
	I don't compare	117	34.4
	Other	51	15.0
Notice of any discrepancies between estimated and actual SMBG (N=340)	Often	39	11.5
	Sometimes	179	52.6
	None	57	16.8
	Never thought about it	65	19.1
Experienced any problems with SMBG device (N=340)	No	232	68.2
	Yes	108	31.8

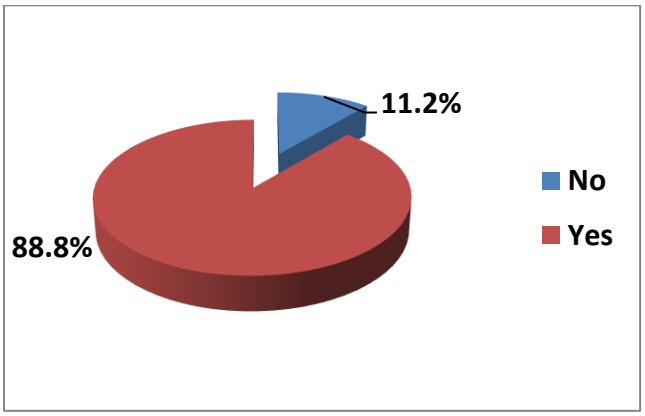

Figure 1 Use SMBG among those who are diabetic (N=383)

We used the 18-item CGM Satisfaction Scale to measure the satisfaction related to SMBG device usage. A five-point Likert scale (strongly agree-5 to strongly disagree-1) was used to assess satisfaction. Out of 18 items, two items were negative statements and the remaining 16 items were positive statements. The responses for each item are given in Table 3. The mean scores of each item showed that the majority of the participants had good satisfaction regarding the use of SMBG. The scores of the two negative items were reversed for the purpose of calculating total satisfaction scores. The total CGM Satisfaction was calculated by adding all 18 items, where a higher score denoted a higher satisfaction. The maximum score that one could get was 90 and the minimum was

18.The mean total satisfaction scores in our study were found to be 74.0 ± 8.5, which shows that majority of the participants had good satisfaction related to SMBG.

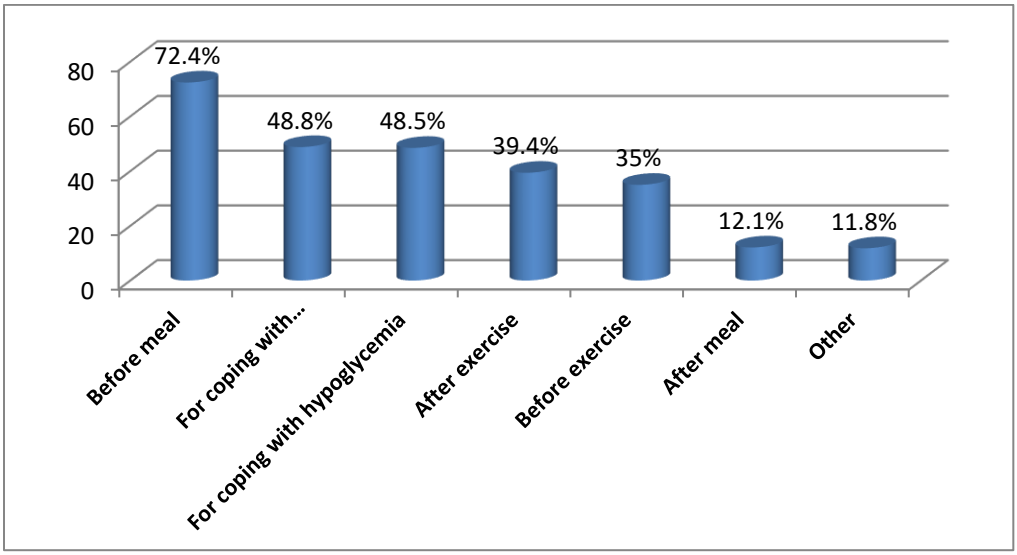

Figure 2 Time of SMBG use (N=340)

Table 3 CGM satisfaction Scale

	Responses (%)					Mean
	SA	A	N	D	SD	
Makes adjusting insulin and/or anti-diabetic medications easier	57.6	29.7	10.3	1.8	.6	4.42 ± 0.7
Helps me to be sure about making diabetes decisions	58.5	28.8	9.7	2.1	.9	4.42 ± 0.8
Makes me think about diabetes too much	35.0	27.6	23.5	12.1	1.8	3.82 ± 1.1
Helps to keep low blood sugars from happening	51.8	34.4	9.1	4.1	.6	4.32 ± 0.8
Teaches me how eating affects blood sugar	57.4	32.1	8.8	1.5	.3	4.44 ± 0.7
Has taught me new things about diabetes that I didn't know before	44.7	32.1	15.9	6.5	.9	4.13 ± 0.9
Helps me to relax, knowing that unwanted changes in blood sugar will be detected quickly	51.2	30.0	15.3	2.6	.9	4.27 ± 0.9
Has helped me to learn how exercise affects blood sugar	51.8	34.7	11.2	2.4	0	4.36 ± 0.7
Helps with keeping diabetes under control on sick days	52.6	31.8	13.5	1.8	.3	4.34 ± 0.8
Has shown me that blood sugar is predictable and orderly	56.2	34.1	8.2	1.2	.3	4.4 ± 0.7
Sometimes gives too much information to work with	44.1	32.9	18.2	3.5	1.2	4.15 ± 0.9
Has made it easier to accept doing blood sugar tests	55.6	33.2	7.6	2.9	.6	4.4 ± 0.8
Is uncomfortable or painful	24.1	19.1	22.6	18.5	15.6	3.1 ± 1.4
Has helped me to learn how to treat low sugars better	55.0	32.4	10.0	2.6	0	4.4 ± 0.7
Helps prevent problems rather than fixing them after they've happened	47.4	34.4	15.9	1.8	.6	4.2 ± 0.8
Allows more freedom in daily life	53.2	32.1	11.2	3.2	.3	4.34 ± 0.8
I recommend this for others with diabetes	53.8	33.2	11.5	1.5	0	4.4 ± 0.7
Helps in adjusting doses of insulin needed through the night	61.5	28.8	8.5	.9	.3	4.5 ± 0.7

The comparison of total CGM Satisfaction between different categorical variables is given in Table 4. There was no statistically significant difference observed in total satisfaction scores between the two genders (p=0.256), between nationalities (p= 0.757) and between those who received information in SMBG and who didn't (p=0.148). However, it was found that participants who used SMBG more than once a day and once a day showed significantly higher scores, whereas those who used it once a month showed lesser scores (p=0.029). There were also no statistically significant differences observed in satisfaction scores between those who encountered problems with SMBG and those who didn't encounter such a problem (p=0.231). At the same time, we found that patients who were on anti-diabetic medications significantly had higher satisfaction scores compared to those who didn't use any

kind of medication (p=0.004). Also, among those who used anti-diabetic medications, patients who were on insulin injections had significantly higher satisfaction scores than those who used oral hypoglycemic drugs (p=0.041).

Table 4 Comparison of CGM Satisfaction Scores

		N	Mean	Std. Deviation	P value
Gender	Female	253	74.3	8.3	0.255
	Male	87	73.1	9.0	
Nationality	Saudi	323	74.0	8.5	0.757
	Non-Saudi	17	73.4	9.1	
Received any explanation on how to use SMBG from your physician	No	77	75.2	8.0	0.148
	Yes	263	73.6	8.6	
Frequency of usage	More than once a day	195	76.9	7.4	0.029
	Once a day	49	74.9	8.4	
	More than once a week	22	72.0	8.8	
	Once a week	40	73.5	8.4	
	More than once a month	19	71.9	8.6	
	Once a month	15	70.6	7.5	
Encountered any problems with the SMBG	No	232	74.3534	8.48554	0.231
	Yes	108	73.1667	8.48803	
On diabetic medication	No	34	70.0588	6.93669	0.004
	Yes	306	74.4118	8.54652	
Type of medication used (N=306)	Insulin injection	214	76.1682	8.62030	0.041
	Oral hypoglycemic medication	78	72.6795	8.10082	
	Other	14	72.5000	8.72441	

4. DISCUSSION

The findings of this study can help improve SMBG outcomes for diabetes patients in Saudi Arabia and provide their perceptions and satisfaction regarding the procedure. To the best of the authors' knowledge, no study has been done in the country that evaluated diabetic patients' experience regarding SMBG use and their satisfaction with its usage in the management of diabetes. The analysis showed that approximately 88.8% of diabetic patients used SMBG and among this, about 57.4% used it more than once a day and 14.4% used it once a day. Through its informational and feedback capabilities, SMBG helps people become more conscious of their current diabetic status. Multiple investigations have uncovered other constructs with significant impact on diabetic self-care (Cameron et al., 2018; Audulv, 2013). These include involvement level, resistance to a diabetic identity, different levels of individual accountability and the difficulties of attempting to maintain a "normal" life. We found that they also impact the implementation of SMBG. It is possible that methods of self-management might evolve and alter with time (Audulv, 2013). Calls for educational initiatives to increase familiarity with SMBG and its operating details have been made. It has also been suggested that educational interventions be made to help people understand how to interpret their results (Austin, 2013). Other research has acknowledged addressing motivation and behavior modification as a priority (Fisher et al., 2011). On the other hand, we have demonstrated that there may be far more basic reasons why people are satisfied with successful SMBG. Individuals SMBG habits and reactions are directly affected by their attitudes and beliefs toward diabetes.

The high degree of SMBG usage observed in our study shows that self-monitoring is feasible for the majority of patients in Saudi Arabia. An Italian study found that non insulintreated individuals with type 2 diabetes who took at least one SMBG reading each day had substantially greater degrees of distress, concerns, anxiety and depression. Higher levels of diabetic health distress and diabetes related anxiety were also shown to be connected to the practice of taking blood sugar readings more frequently than once per week (Franciosi et al., 2001). It was reported by Watkins et al., (2000) that dietary adherence and other diabetes specific health habits might significantly impact the quality of life by raising the amount of perceived diabetes related burden. One may hypothesize that newly diagnosed Type 2 diabetes patients are more likely to adhere to healthcare expert recommendations about testing frequency and subsequent action. Unfortunately, this was not assessed in our study. Our findings showed that patients who were on anti-diabetic medications had higher satisfaction than those who didn't take any kind of medication. Also, it was found that

patients who were on insulin injections were more satisfied with SMBG than others who were on oral hypoglycemic medication and other methods.

Some researchers have hypothesized that the inability to identify a link between SMBG and better glycemic control is due to a lack of knowledge about what these measures indicate, how they should be utilized and how patients could adjust their insulin dosage or other behaviors based on the results (Heller, 2014). It should be speculated that diabetes patients who keep diaries of their daily food intake and SMBG readings report feeling better in control of their condition and its management. For individuals with a more severe and prolonged course of diabetes, this may first be puzzling or worrisome. Satisfaction may improve, however, if people with diabetes embrace the diagnosis and are prepared to make lifestyle changes. Self-monitoring likely benefited patients since it served as an instructional tool and staff attention to them improved (Shrivastava et al., 2013). Patients with diabetes who take insulin and those who do not have a similar need but different priorities. It was reported by Peel et al., (2007) that patients with type 2 diabetes who did not inject insulin responded to monitoring data by changing their diet and exercise routines. Additionally, there were differences in the duration and frequency with which they monitored their blood glucose, maybe because they wanted to live life to the fullest despite having diabetes. When it came to managing their diabetes, insulin users were hyperfocused on their insulin dosages. SMBG was thought to be useful in the prevention and diagnosis of hypo and hyperglycemic episodes since some patients with autonomic nerve injury had lost awareness of their symptoms (Hortensius et al., 2012). The findings of our study showed that the majority of the patients were satisfied with the usage of SMBG. The technical and operational elements of the devices, the training received and the variations between child and adult patients are only a few of the possible explanations for why our findings differ from those of the prior research. Patients will continue to rely on SMBG as their primary tool for self-care control of glucose readings until a cure is found. Individuals can learn about the fluctuating course of their blood glucose with the use of SMBG. The findings of our study can be useful for planning diets, workouts and treatment adherence. Self-management of Diabetes and strict adherence to treatment standards, such as SMBG, are essential for effective diabetes control (Carol et al., 2011; Hirsch et al., 2008). If used correctly, SMBG has the potential to significantly enhance patients' understanding of their glucose levels and the consequences of their actions on those levels. Further longitudinal studies are warranted to determine if and how often educating people on how to interpret SMBG and respond to out-of-range blood glucose levels can enhance control and decrease anxiety. The findings of this study lend credence to the idea that clinicians may shape patients' perspectives and methods for managing their healthcare experiences but that patients' satisfaction and own decisions ultimately determine their behavior. Some of the limitations of this research should be highlighted before interpreting the findings. Firstly, we used a self-administered online questionnaire, which might have resulted in self-reported bias and/or social desirability bias when reporting responses for many questions. Secondly, there was unequal gender distribution in the sample, which might have failed to give actual differences in satisfaction between the two genders.

5. CONCLUSION

The study showed moderate to high satisfaction with using SMBG among diabetic patients, irrespective of the type of diabetes they experienced. The satisfactions were higher among those who were on anti-diabetic medication and also those who were on insulin therapy. Patients who used SMBG more than once daily showed better satisfaction than others. Achieving good care of patients with either kind of diabetes requires better self-glucose monitoring experiences. More studies should be undertaken to evaluate the cost of the approaches, the user's training and the capacity to support insulin/diet calculations because user satisfaction is crucial as new technologies emerge.

Informed consent

Written & Oral informed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants for whom identifying information is included in this manuscript.

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We thank the participants who were all contributed samples to the study. Author Contributions We certify, as authors, that we have participated sufficiently in the intellectual content, conception and design of this work or the analysis and interpretation of the data, as well as the writing of the manuscript, to take public responsibility for it and have agreed to have our name listed as a contributor. All persons who have made substantial contributions to the work reported in the manuscript.

Ethical approval

Permission for conducting the study was taken from the Research and Ethics Committee of Taif University, with letter number (44-046).

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Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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